

ENERGY EFFICIENCY AND CARBON EMISSION CALCULATION METHOD AND APPARATUS FOR DATA CENTER, AND ELECTRONIC DEVICE

[0001] This application claims priority to the Chinese patent application titled "ENERGY EFFICIENCY AND CARBON EMISSION CALCULATION METHOD AND APPARATUS FOR DATA CENTER, AND ELECTRONIC DEVICE" with application number 202211027486.9, submitted to the Chinese Patent Office on August 25, 2022, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to energy and carbon emission management technology in the field of computer applications, and more specifically, to energy efficiency and carbon emission calculation methods and apparatuses for a data center, electronic devices, storage media, data centers, and computer program products.

BACKGROUND

[0003] In September 2020, China explicitly proposed the goals of the "peak carbon dioxide emissions" by 2030 and the "carbon neutral" by 2060. On July 16, 2021, the national carbon emission trading market opened, and carbon emission parameters (referred to as carbon emissions) gradually became a production indicator of concern for various production participants.

[0004] The Internet Data Center (IDC, hereinafter referred to as the data center) has a large energy consumption and carbon emissions. At present, some cities have carried out pilot projects of incorporating the carbon emission of the data center into the carbon emission market, and the carbon emission of the data center may be incorporated into the national unified carbon emission market in the future. The important link for incorporating the carbon emission of the data center into the carbon emission market is the establishment of the carbon emission benchmark and the allocation of carbon emission quotas. Currently, there is significant space for optimization in the relevant systems and rules. Therefore, it is necessary to propose energy efficiency and carbon emission calculation methods for data centers, which is of great significance for assisting data center carbon emission management and promoting green and low-carbon development of data centers.

SUMMARY

[0005] The present disclosure provides an energy efficiency and carbon emission calculation method and apparatus for a data center, and an electronic device, which aims to achieve a comprehensive efficiency evaluation of the entire chain from energy input to performance output in the calculation process of energy efficiency and carbon emissions parameters in data centers. This provides guidance for optimizing carbon emission parameters in data centers and helps promote the healthy development of the data center industry.

[0006] To achieve the above technical objectives, the embodiments of the present disclosure provide the following technical solutions.

[0007] In the first aspect, the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation method for a data center, including:

[0008] obtaining energy efficiency parameters of the data center, where the energy efficiency parameters include resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness;

[0009] determining weights respectively corresponding to the energy efficiency parameters of the data center; and determining, based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, comprehensive energy efficiency of the data center, where the comprehensive energy is configured to calculate carbon emissions of the data center.

[0010] In the second aspect, the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation method for a data center, including:

[0011] obtaining energy efficiency parameters of the data center, where the energy efficiency parameters are configured to represent the resource usage effectiveness and computing power usage and output state of the data center;

[0012] determining comprehensive energy efficiency of the data center by integrating the energy efficiency parameters of the data center.

[0013] In the third aspect, the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation apparatus for a data center, including:

[0014] a first energy efficiency obtaining module, configured to obtain energy efficiency parameters of the data center, where the energy efficiency parameters include resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness; and

[0015] a first energy efficiency determining module, configured to determine weights respectively corresponding to the energy efficiency parameters of the data center; and determine, based on the energy efficiency parameters of the data center and the weights

respectively corresponding to the energy efficiency parameters, comprehensive energy efficiency of the data center, where the comprehensive energy is configured to calculate carbon emissions of the data center.

[0016] In the fourth aspect, the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation apparatus for a data center, including:

[0017] a second energy efficiency obtaining module, configured to obtain energy efficiency parameters of the data center, where the energy efficiency parameters are configured to represent the resource usage effectiveness and computing power usage and output state of the data center;

[0018] a second energy efficiency determining module, configured to determine the comprehensive energy efficiency of the data center by integrating the energy efficiency parameters of the data center, where the comprehensive energy efficiency is used to calculate the carbon emissions of the data center.

[0019] In the fifth aspect, the embodiments of the present disclosure provide an electronic device including: one or more memories and one or more processors;

[0020] where the one or more memories are connected to the one or more processors, and the one or more memories are configured to store a program;

[0021] the one or more processors are configured to implement, by running the program stored in the one or more memories, the energy efficiency and carbon emission calculation method for a data center according to any one of the above aspects.

[0022] In the sixth aspect, the present disclosure provides a storage medium on which a computer program is stored. When the computer program is executed by a processor, the energy efficiency and carbon emission calculation method for a data center as described in any one of the above is implemented.

[0023] In the seventh aspect, the embodiments of the present disclosure also provide a data center including: IT equipment and calculating equipment connected to the IT equipment, where the calculating equipment is configured to implement the energy efficiency and carbon emission calculation method for a data center according to any one of the above.

[0024] In the eighth aspect, the embodiments of the present disclosure provide a computer program product or computer program including computer instructions stored in a computer-readable storage medium; a processor of a computer device reads the computer instructions from the computer-readable storage medium, and when the processor executes the computer instructions, the energy efficiency and carbon emission calculation method for the data center as described above is implemented.

[0025] From the above technical solutions, it can be seen that the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation method and apparatus for a data center, an electronic device, a storage medium, a data center, and a computer program product. In the process of determining carbon emission parameters, this method comprehensively considers resource usage effectiveness, computing power usage and output state as energy efficiency parameters, realizing a full chain comprehensive efficiency evaluation system for energy input and performance output of data centers, taking into account resource efficiency, computing power, and computing efficiency of data centers, comprehensively reflecting the comprehensive efficiency level of data centers, overcoming the problem of traditional carbon emission quota verification methods not being able to reflect the all-link comprehensive efficiency of energy usage and computing power output of data centers, providing certain guidance for optimizing the carbon emission parameters of data centers, and providing assistance for the good development of the data center industry.

BRIEF DESCRIPTION OF DRAWINGS

[0026] In order to provide a clearer explanation of the embodiments of the present disclosure or technical solutions in traditional technologies, the drawings needed in the description of the embodiments or the traditional technology are briefly introduced below. The drawings in the following description are only some embodiments of the present disclosure. Those of ordinary skill in the art can also obtain other drawings based on these drawings without exerting creative efforts.

[0027] FIG. 1 is a schematic diagram of a scenario according to an embodiment of the present disclosure.

[0028] FIG. 2 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to an embodiment of the present disclosure.

[0029] FIG. 3 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0030] FIG. 4 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0031] FIG. 5 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0032] FIG. 6 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0033] FIG. 7 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0034] FIG. 8 is a schematic diagram of an interface displaying an energy efficiency optimization report according to an embodiment of the present disclosure.

[0035] FIG. 9 is a schematic diagram of an interface displaying an energy efficiency optimization report according to another embodiment of the present disclosure.

[0036] FIG. 10 is a flowchart of an energy efficiency and carbon emission calculation method for a data center according to another embodiment of the present disclosure.

[0037] FIG. 11 is a schematic structural diagram of an energy efficiency and carbon emission calculation apparatus for a data center according to an embodiment of the present disclosure.

[0038] FIG. 12 is a schematic structural diagram of an energy efficiency and carbon emission calculation apparatus for a data center according to another embodiment of the present disclosure.

[0039] FIG. 13 is a schematic structural diagram of a data center according to an embodiment of the present disclosure.

[0040] FIG. 14 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0041] Unless otherwise defined, the technical terms or scientific terms used in the present disclosure shall have the ordinary meanings understood by those skilled in the art to which the present disclosure belongs. The terms "first", "second", and similar words used in the embodiments of the present disclosure do not indicate any order, quantity, or importance, but are only used to avoid confusion of constituent elements.

[0042] Unless otherwise required by the context, throughout the entire specification, "multiple" means "at least two", and "including" is interpreted as open and inclusive, meaning "including, but not limited to". In the description of the present disclosure, the terms "an embodiment", "some embodiments", "exemplary embodiments", "examples", "specific examples" or "some examples" are intended to indicate that specific features, structures, materials or characteristics related to the embodiment(s) or example(s) are included in at least one embodiment or example of the present disclosure. The schematic representation of the above terms does not necessarily refer to the same embodiment or example.

[0043] The technical solutions in the embodiments of the present disclosure are clearly described below with reference to the accompanying drawings in the embodiments of the

present disclosure. The embodiments described are merely some embodiments of the present disclosure, and not all embodiments. Other embodiments achieved by those of ordinary skill in the art based on the embodiments in the present disclosure without paying creative work shall all fall within the scope of protection of the present disclosure.

[0044] As an entity for storing, computing, and interacting with massive amounts of data, a data center includes devices such as computing, cooling, power supplying, lighting, and machinery devices, which is also the data hub and computing carrier for technologies such as 5G, artificial intelligence (AI), the Internet of Things, and cloud computing, and is an important support for the development of "new infrastructure".

[0045] The server clusters and auxiliary cooling systems in the data center are high-energy-consuming equipment that are highly dependent on electricity for uninterrupted operation. According to the "Data Center White Paper (2022)" released by the China Academy of Information and Communications Technology in April 2022, the energy consumption of data centers in China in 2021 was approximately 216.6 billion kilowatt hours, accounting for 2.6% of the total electrical energy consumption in the country. The indirect greenhouse gas emissions generated by electrical energy consumption reached approximately 135 million tons, accounting for about 1.14% of the carbon emissions in the country. Over the past decade, the overall electrical energy consumption of China's data center industry has been increasing at an average annual rate of over 10%. With the increase in overall energy demand, the issue of energy consumption in data centers has received high attention. In order to promote consumption reduction and carbon reduction in data centers, the country plans to include data centers in the national unified carbon market, thereby promoting emission data monitoring, reporting, and verification, promoting the implementation of industry energy efficiency standards, and using market mechanisms to minimize the total cost of emission reduction in the industry.

[0046] Therefore, in the face of the industry development background where data centers are about to be included in the carbon emission market, key issues such as carbon emission quota allocation in the mechanism design of data centers in the carbon emission market, and how to accurately and reasonably calculate energy efficiency and carbon emissions of data centers, have become urgent problems to be solved. Accurate and reasonable energy efficiency and carbon emission calculating can provide a carbon emission reference for enterprises engaged in the data center industry, guide enterprises to optimize equipment emissions, and enhance the scientificity of the carbon emission benchmark value and carbon emission allocation process in the data center industry.

[0047] In one scenario example of the present disclosure, referring to FIG. 1, the energy consumption and carbon emissions generated by data centers during operation are usually evaluated using Usage Effectiveness indicators. The resource usage measurement indicators involved in Usage Effectiveness indicators mainly include Power Usage Effectiveness (PUE), Water Usage Efficiency (WUE), Carbon Use Efficiency (CUE), Infrastructure Usage Efficiency (IUE), and Grid Usage Efficiency (GUE). Below is an introduction to the commonly used PUE:

$$PUE = P_{\text{total}} / P_{\text{IT}} \quad (1)$$

[0048] P_{total} refers to the total electrical energy consumption of the data center, measured in kilowatt hours.

[0049] P_{IT} refers to the electrical energy consumption of IT (Information Technology) equipment in a data center, measured in kilowatt hours.

[0050] IT equipment is the fundamental device for generating computing power in data centers, which can include servers, storage devices, and network devices.

[0051] In addition, the reciprocal of PUE is called data center infrastructure efficiency $DCiE = 1/PUE$, where $DCiE$ reflects the proportion of the energy efficiency of IT equipment in the total energy efficiency of the data center. Its value is less than 1, and the closer it is to 1, the better.

[0052] The derivative efficiencies of PUE include pPUE (partial power usage efficiency), dPUE (design power usage efficiency), and iPUE (interim power usage efficiency). Where dPUE is the expected PUE determined by the design goal of the data center, and iPUE refers to the PUE measured at a specified time, not the annual value.

$$pPUE = P_{\text{total_sub}} / P_{\text{IT_sub}} \quad (2)$$

[0053] $P_{\text{total_sub}}$ refers to the total electrical energy consumption in a subsystem (power distribution system, network equipment, or cooling system, etc.) of the data center, measured in kilowatt hours.

[0054] $P_{\text{IT_sub}}$ refers to the electrical energy consumption of IT equipment in data centers, measured in kilowatt hours.

[0055] In addition, the relevant standards for energy consumption assessment of data centers in the country further include: EEUE-R (Electric Energy Usage Effectiveness-Real value), EEUE-X (Electric Energy Usage Efficiency-Corrected value), WUE (Water Usage Effectiveness), CUE (Carbon Usage Effectiveness), IUE (Infrastructure Usage Effectiveness), GUE (Grid Usage Effectiveness), REF (Renewable Energy Factor), ERF (Energy Reuse Factor), and SEUR (Storage Energy Use Ratio).

[0056] These indicators focus on the analysis of the consumption, conversion, and utilization structure of data center power and water resources. Except for PUE, most indicators are computationally complex and difficult to widely accept. Moreover, the above indicators cannot reflect the computing power output supported by data centers in the process of resource consumption, cannot cover the entire chain of energy conversion and application in data centers, and cannot provide a comprehensive perspective on the overall efficiency of data centers.

[0057] In view of this, the embodiments of the present disclosure provide an energy efficiency and carbon emission calculation method of data centers. In the process of determining comprehensive energy efficiency, this method comprehensively considers resource usage effectiveness, computing power usage and output state as energy efficiency parameters, realizing a full chain comprehensive efficiency evaluation system for energy input and performance output of data centers, taking into account resource efficiency, computing power, and computing efficiency of data centers, comprehensively reflecting the comprehensive efficiency level of data centers, overcoming the problem of traditional carbon emission quota verification methods not being able to reflect the all-link comprehensive efficiency of energy usage and computing power output of data centers, providing certain guidance for optimizing the energy efficiency benchmark value of data centers, and providing assistance for the good development of the data center industry.

[0058] In addition, the energy efficiency calculation method further determines the weights respectively corresponding to the energy efficiency parameters of the data center based on the attributes of data centers, such that in the process of determining the energy efficiency benchmark value of the data center, the corresponding energy efficiency parameter weight can be determined according to the different attributes of the data centers, which lays the foundation for determining the targeted energy efficiency benchmark values of data centers with different attributes and improves the pertinence of the energy efficiency and carbon emission calculation methods for the data centers.

[0059] Below, combined with feasible exemplary embodiments, the energy efficiency and carbon emission calculation method of the data center provided in the embodiments of the present disclosure will be explained.

[0060] An exemplary embodiment of the present disclosure provides an energy efficiency and carbon emission calculation method for a data center, as shown in FIG. 2, including steps S101 to S102.

[0061] In step S101, energy efficiency parameters of the data center are obtained, where the energy efficiency parameters are configured to represent the resource usage effectiveness and computing power usage and output state of the data center.

[0062] In step S101, in addition to resource usage effectiveness, the computing power usage and output state are also included as part of the energy efficiency parameters. That is, In the process of evaluating the comprehensive energy efficiency of the data center, not only the energy consumption of the data center is considered, but also the computing power output supported by energy consumption is taken into account, which ensures that the energy efficiency parameters used to determine the comprehensive energy efficiency cover the entire process from energy usage to performance output, and considers the comprehensive energy efficiency of the data center from multiple dimensions, ensures the determination of the comprehensive energy efficiency comprehensively reflects the comprehensive energy efficiency level of the data center, effectively overcomes the problem that current comprehensive energy efficiency determination methods cannot fully reflect the comprehensive efficiency of the entire process of energy usage and computing power output of the data center.

[0063] In an embodiment of the present disclosure, "resources" in resource usage effectiveness refers to the resources used by the data center, including at least one of energy resources, water resources, cooling resources, and space resources occupied by rack units. Where water resources can include water used for server cooling and room humidification in data centers, cooling resources can include coolant used in data centers other than cooling water, and energy sources used in data centers include but are not limited to at least one of electrical energy, light energy, or thermal energy. Correspondingly, resource usage effectiveness refers to the usage effectiveness of resources used by data centers. In some embodiments, taking the electrical energy used in data centers as an example, resource usage effectiveness can be the PUE introduced earlier, or indicators reflecting power usage efficiency such as pPUE, dPUE, or iPUE. The specific definitions and calculation methods of pPUE, dPUE, and iPUE can refer to the description above. In addition, resource usage effectiveness can also be indicators reflecting the usage effectiveness of other resources introduced earlier, which is not limited in the present disclosure.

[0064] The parameters used to represent the usage and output state of computing power can be the computing power usage effectiveness and computing power energy effectiveness of the data center, or parameters further processed (such as through normalization, or standardization, etc.) based on the computing power usage effectiveness and computing power energy

effectiveness, which is not limited in the present disclosure. In data centers, IT equipment includes computing devices, storage devices, and network devices, where the computing part consumes the most energy, accounting for more than 90% of the total energy consumption of IT equipment. Therefore, Computational Energy Usage Efficiency (CEUE) representing the energy consumption effectiveness of the computing part can evaluate the energy efficiency of data centers from the dimension of the computing power energy effectiveness of the data center.

[0065] For computing power usage effectiveness, an average usage rate of the computing power of the data center within a specific time period can be used as a representing value of the computing power usage effectiveness, or an average idle rate of computing power of the data center within a specific time period can be used as a representing value of the computing power usage effectiveness. Computing power can refer to the computing power that processes information data to achieve the output of target results. In data centers, computing power can be represented by the CPU (Central Processing Unit) resources of servers. The computing power usage effectiveness can evaluate the energy efficiency of the data center from the dimension of computing power usage. That is, when the representing value of computing power usage effectiveness refers to the average usage rate of computing power in a data center during a specific period of time, it can be represented as the average usage rate of server CPUs in the data center during a specific period of time, denoted as η_{CPU} , in %, which can be specifically represented as:

$$\eta_{\text{CPU}} = \text{CPU}_{\text{U}} / \text{CPU}_{\text{tot}} \quad (3)$$

[0066] Where CPU_{U} refers to the used CPU resources, in Hz, and CPU_{tot} refers to the total CPU resources, in Hz. When the representing value of computing power usage refers to the average idle rate of computing power in a data center during a specific period of time, the representing value of computing power usage effectiveness can be represented as $1 - \eta_{\text{CPU}}$.

[0067] In step S102, the comprehensive energy efficiency of the data center is determined by integrating the energy efficiency parameters of the data center, where the comprehensive energy efficiency is used to calculate the carbon emissions of the data center.

[0068] In step S102, the comprehensive energy efficiency of the data center is determined by considering three dimensions: resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness, which achieves a multi-dimensional comprehensive evaluation of the entire process from energy usage to performance output of the data center, makes the determined comprehensive energy efficiency more scientifically and accurately reflect the energy efficiency output state of the data center, and lays a solid

foundation for scientifically formulating carbon emission benchmarks and free carbon emission quotas for the data center.

[0069] When the comprehensive energy efficiency is determined by integrating the energy efficiency parameters of the data center, the energy efficiency parameters may be directly added, or weights may be assigned to the energy efficiency parameters and then the energy efficiency parameters may be added, or the comprehensive energy efficiency may be obtained by calculation according to a preset formula, which is not limited in the present disclosure, and depends on the actual situation.

[0070] In addition, scientific and accurate comprehensive energy efficiency can also guide the data center to optimize energy efficiency and contribute to energy conservation, emission reduction, and energy efficiency improvement in the data center.

[0071] Due to the correlation between the comprehensive energy efficiency of the data center and carbon emissions of the data center, after determining the comprehensive energy efficiency of the data center, the carbon emissions of the data center can be calculated based on the comprehensive energy efficiency.

[0072] For data centers with different attributes, the weights of various energy efficiency parameters may vary. In order to achieve accurate calculating of energy efficiency and carbon emissions for data centers with different attributes, an embodiment of the present disclosure provides an energy efficiency and carbon emission calculation method for another data center, as shown in FIG. 3, including steps S201 to S202.

[0073] In step S201, energy efficiency parameters of the data center are obtained, where the energy efficiency parameters include resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness.

[0074] In step S201, the computing power usage effectiveness and computing power energy effectiveness are used as parameters to represent the states of computing power usage and computing power output. The computing power energy effectiveness can be calculated based on the computational power usage efficiency that represents the computing power part of IT equipment, or based on the parameter that represents the energy efficiency of the storage part or the network part of IT equipment, which is not limited in the present disclosure.

[0075] The computing power energy effectiveness can be represented not only by the computational power usage efficiency itself, but also by the parameter obtained by normalizing the computational power usage efficiency. For example, the computing power energy effectiveness can be represented as:

$$\eta_{\text{CEUE}} = (\text{CEUE true value} - \text{CEUE benchmark value}) / \text{CEUE benchmark value} \quad (4)$$

[0076] Among them, CEUE refers to the power consumption of IT equipment required per unit of computing power in a data center, measured in W/TFLOPS. The calculation formula may refer to formula (5):

$$CEUE = P_{IT} / CP \quad (5)$$

[0077] Where P_{IT} refers to the total power of IT equipment, measured in kW, CP refers to the computing power of the data center, measured in FLOPS (Floating-point Operations Per Second, the number of floating-point operations performed per second), used to evaluate the general computing power and high-performance computing power of the data center. The CEUE benchmark value can be determined by the recently published national data center overall computational energy usage efficiency value, or by the average of the national data center overall computational energy usage efficiency values published in the past two years.

[0078] In step S202, weights respectively corresponding to the energy efficiency parameters of the data center are determined; and comprehensive energy efficiency of the data center is determined based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, where the comprehensive energy is configured to calculate carbon emissions of the data center.

[0079] After the weights respectively corresponding to the energy efficiency parameters are determined, a sum of products of the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters can be determined as the comprehensive energy efficiency of the data center. Due to the various ways in which energy efficiency parameters of the data center can be represented, more specifically, the comprehensive energy efficiency of the data center can be determined by multiplying the representing values of resource usage effectiveness, computing power energy effectiveness, and computing power usage effectiveness with their corresponding weights. If the PUE is used as the representing value of the resource usage effectiveness, the representing value of the computing power usage effectiveness is represented by $1 - \eta_{CPU}$, and the computing power energy effectiveness η_{CEUE} of IT equipment is used as the representing value of the computing power energy effectiveness, the comprehensive energy efficiency can be calculated according to the following formula (6):

$$S_{tot} = k_1 \cdot (PUE) + k_2 \cdot (1 - \eta_{CPU}) + k_3 \cdot \eta_{CEUE} \quad (6)$$

[0080] Where S_{tot} represents the comprehensive energy efficiency, PUE represents power usage effectiveness, η_{CPU} represents the average usage rate of computing power in the data center during a specific period of time, and η_{CEUE} represents the computing power energy effectiveness of IT equipment. K_1 represents the weight corresponding to resource usage

effectiveness (in this embodiment, power usage effectiveness), k_2 represents the weight corresponding to the representing value of computing power usage effectiveness, and k_3 represents the weight corresponding to computing power energy effectiveness (in this embodiment, the computing power energy effectiveness of IT equipment).

[0081] In some embodiments, determining the weights respectively corresponding to the energy efficiency parameters of the data center includes step S2021.

[0082] In step S2021, the weights respectively corresponding to the energy efficiency parameters of the data center are determined based on an attribute of the data center, where the attribute of the data center is configured to represent a type, an operating environment, and an operating state of the data center.

[0083] As mentioned earlier, due to the different attributes of data centers, the contributions of resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness to the comprehensive energy efficiency of data centers also varies. Therefore, it is necessary to determine the weights respectively corresponding to the energy efficiency parameters of the data center based on the attribute of the data center.

[0084] The types of data centers include but are not limited to super large data centers, large data centers, medium-sized data centers, and small data centers classified by scale, or enterprise self use data centers and third-party hosting data centers classified by operation, or A-level data centers, B-level data centers, and C-level data centers classified by GB50174-2008 standard.

[0085] The operating environment of the data center may include the region where the data center is located, and the current season, etc. In some embodiments, the operating environment of the data center may further include incentives for the region where the data center is located.

[0086] The operating state of the data center includes but is not limited to the purpose of the data center and the type of data center. The purpose of the data center includes but is not limited to data storage, data processing and analysis, and product services.

[0087] When the attributes of data centers are different, the contribution of each energy efficiency parameter to the comprehensive energy efficiency varies. For example, data center 1 and data center 2 are respectively located in city A and city B. City A has a shortage of electricity, and electricity is allocated from other cities for use all year round. City B is rich in resources such as water, wind, and solar energy, with complete supporting hydroelectric, wind, and solar power stations. Various types of power stations can not only meet the electricity needs of the city, but also transmit a large amount of electricity to other cities. In this case, the weight of resource usage effectiveness of data center 1 located in City A can be greater than the weight of resource usage effectiveness of data center 2 located in City B. This is because the resources

and costs (such as transmission costs) required for data center 1 to use one kilowatt hour of electricity are greater than the resources and costs required for data center 2 to use one kilowatt hour of electricity.

[0088] For example, Data Center 3 is located in City C in the north, which has extremely cold winters and requires a large amount of electricity, heat, and other resources to meet heating needs. However, City C has a pleasant summer climate and does not need to meet the electricity demand for air conditioning and cooling equipment like other cities. Therefore, the weight of the resource usage effectiveness of Data Center 3 in winter can be greater than the weight of the resource usage effectiveness of Data Center 3 in summer. The present disclosure does not provide an exhaustive list of various situations, and the determination of the weight of various energy efficiency parameters depends on the actual situation.

[0089] After establishing a comprehensive energy efficiency determination method similar to formula (6), a data center comprehensive performance evaluation system can also be established based on the determining method. For example, as shown in FIG. 4, the energy efficiency and carbon emission calculation method for the data center further includes steps S301 to S307.

[0090] In step S301, for each of the energy efficiency parameters, a first typical value, a second typical value, and a third typical value for the energy efficiency parameter are obtained, where the first typical value represents a typical value for the energy efficiency parameter in a first energy efficiency region, the second typical value represents a typical value for the energy efficiency parameter in a second energy efficiency region, and the third typical value represents a typical value for the energy efficiency parameter in a third energy efficiency region; where energy efficiency in the first energy efficiency region, the second energy efficiency region, and the third energy efficiency region represented by the energy efficiency parameter sequentially decreases.

[0091] The first typical value, second typical value, and third typical value refer to the typical values of each energy efficiency parameter of the data center in an advanced region (i.e., the first energy efficiency region, which can be considered as the high energy efficiency region), a general region (i.e., the second energy efficiency region, which can be considered as the general energy efficiency region), and a backward region (i.e., the third energy efficiency region, which can be considered as the low energy efficiency region). The typical values can be the median or average of data centers in the data center industry within the above ranges, which is not limited in the present disclosure.

[0092] Referring to Table 1, Table 1 shows a feasible first typical value, second typical value, and third typical value corresponding to each of PUE, computing power usage effectiveness, and computing power energy effectiveness.

Table 1 Typical values of energy efficiency parameters for data center

Classification	Typical values for PUE	Typical value of $(1-\eta_{\text{CPU}})$, representing numerical typical value of computing power usage effectiveness	Computing power energy effectiveness, typical value of η_{CEUE}	S_{tot} typical value (Comprehensive Energy Efficiency Typical Value)
First typical value	1.2	30%	-0.6	60 (first energy efficiency typical value)
Second typical value	1.4	70%	0	140 (Second energy efficiency typical value)
Third typical value	1.8	90%	0.6	240 (Third energy efficiency typical value)

[0093] In step S302, a sum of products of first typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters is determined as a first energy efficiency typical value.

[0094] Taking the first typical value in Table 1 as an example, taking $k_1=50$, $k_2=100$, $k_3=50$ in formula (6) as an example, the first energy efficiency typical value is $1.2 \times 50 + 100 \times 30\% + (-0.6) \times 50 = 60$.

[0095] In step S303, a sum of products of second typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters is determined as a second typical energy efficiency value.

[0096] Taking the second typical value in Table 1 as an example, taking $k_1=50$, $k_2=100$, $k_3=50$ in formula (6) as an example, the second energy efficiency typical value is $1.4 \times 50 + 100 \times 70\% + 0 \times 50 = 140$.

[0097] In step S304, a sum of products of third typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters is determined as a third typical energy efficiency value.

[0098] Taking the third typical value in Table 1 as an example, taking $k_1=50$, $k_2=100$, $k_3=50$ in formula (6) as an example, the third energy efficiency typical value is $1.8 \times 50 + 100 \times 90\% + 0.6 \times 50 = 210$.

[0099] Still referring to Table 1, Table 1 also shows the energy efficiency typical value t calculated based on the obtained energy efficiency parameters.

[0100] It is not difficult to understand that the smaller the S_{tot} , the better the resource usage and computing power output of the data center.

[0101] In step S305, a first critical value between the first energy efficiency typical value and the second energy efficiency typical value is determined.

[0102] In step S306, a second critical value between the second energy efficiency typical value and the third energy efficiency typical value is determined.

[0103] In step S307, based on a relationship between the comprehensive energy efficiency of the data center and the first critical value and the second critical value, an energy efficiency state of the data center is determined, where the efficiency state is configured to represent an energy efficiency level of the comprehensive energy efficiency of the data center.

[0104] The first critical value can be between the first energy efficiency typical value and the second energy efficiency typical value, serving as the boundary between an excellent level and a good level of the comprehensive energy efficiency in the data center. The second critical value can be between the second energy efficiency typical value and the third energy efficiency typical value, serving as the boundary between the good level and a poor level of the comprehensive energy efficiency in the data center.

[0105] Referring to Table 2, Table 2 shows a feasible comprehensive performance level classification system for data centers. In Table 2, the first critical value is taken as the average (e.g., 100) of the first energy efficiency typical value (e.g., 60) and the second energy efficiency typical value (e.g., 140), and the second critical value is taken as the average (e.g., 190) of the

second energy efficiency typical value (e.g., 140) and the third energy efficiency typical value (e.g., 210).

Table 2 Comprehensive Performance Level Classification System for Data Centers

#	Energy efficiency level	Comprehensive energy efficiency level range
1	excellent	Comprehensive energy efficiency $\leq$ first critical value (e.g., 100)
2	good	First critical value (e.g., 100) $<$ Comprehensive energy efficiency $\leq$ Second critical value (e.g., 190)
3	Poor	Comprehensive energy efficiency $>$ second critical value (e.g., 190)

[0106] Combining Table 2, it can be found that after determining the first critical value and the second critical value, the energy efficiency state of the data center can be evaluated based on the relationship between the comprehensive energy efficiency of the data center and the first critical value and the second critical value. This energy efficiency state represents the energy efficiency level of carbon emissions of the data center. Taking Table 2 as an example, when the comprehensive energy efficiency of a data center is less than or equal to the first critical value, it can be considered that the comprehensive energy efficiency of the data center is at an excellent level, indicating that the energy efficiency and computing power output of the data center are excellent. When the comprehensive energy efficiency of a data center is greater than the first critical value and less than or equal to the second critical value, it can be considered that the comprehensive energy efficiency of the data center is at a good level, indicating that the energy efficiency and computing power output of the data center are good. When the comprehensive energy efficiency of the data center is greater than the second critical value, it can be considered that the comprehensive energy efficiency of the data center is at a poor level, indicating that the energy efficiency and computing power output of the data center are poor, and it is necessary to optimize the energy efficiency of the data center to improve the comprehensive energy efficiency.

[0107] For example, in Table 2, when the comprehensive energy efficiency of the data center is equal to the first critical value, the energy efficiency level of the comprehensive energy efficiency of the data center is classified as excellent. When the comprehensive energy efficiency of the data center is equal to the second critical value, the energy efficiency level of the comprehensive energy efficiency of the data center is classified as good. In some embodiments, when the comprehensive energy efficiency of the data center is equal to the first critical value, the energy efficiency level of the comprehensive energy efficiency of the data center can also be classified as good. Similarly, when the comprehensive energy efficiency of the data center is equal to the second critical value, the energy efficiency level of the comprehensive energy efficiency of the data center can also be classified as poor. The present disclosure does not limit this, and it depends on the actual situation.

[0108] In addition to evaluating the energy efficiency state of the data center based on the relationship between the comprehensive energy efficiency of the data center and the first and second critical values, referring to FIG. 5, the energy efficiency and carbon emission calculation method of the data center also includes step S401.

[0109] In step S401, an energy efficiency benchmark value of the data center is determined based on the first critical value and the second critical value, and a carbon emission benchmark value of the data center is determined based on the energy efficiency benchmark value of the data center.

[0110] After the boundary point (i.e., the first critical value and the second critical value) of the energy efficiency level of comprehensive energy efficiency of the data center is determined, the energy efficiency benchmark value that represents the mainstream energy efficiency level of the data center can be determined based on the critical value, and the carbon emission benchmark value can be further determined based on the energy efficiency benchmark value. The carbon emission benchmark value can be used as the basis for determining the free carbon emission quota, promoting the progress of integrating the data center into the carbon emission market.

[0111] In some embodiments, the energy efficiency benchmark value can be between the first critical value and the second critical value, that is, the energy efficiency benchmark value is greater than the first critical value and less than the second critical value. The energy efficiency benchmark value can also be equal to the average of the sum of the first critical value and the second critical value. Taking the first critical value of 100 and the second critical value of 190 as an example, the energy efficiency benchmark value greater than 100 and less than 190 can represent the mainstream carbon emission level of the data center. Of course, the energy

efficiency benchmark value can be determined as the average of the sum of 100 and 190 (i.e., 145), or it can be determined closer to the second critical value (e.g., 150, 155, or 160, etc.), such that more data centers can have their annual energy efficiency benchmark values within the free carbon emission quota, to encourage the development of the data center industry.

[0112] The carbon emission benchmark value of the data center can also be obtained according to the mapping of the energy efficiency benchmark value of the data center, such as in a proportional relationship.

[0113] As mentioned earlier, the first, second, and third typical values corresponding to each energy efficiency parameter in Table 1 may change with the continuous development of the data center industry. Therefore, in an embodiment of the present disclosure, referring to FIG. 6, the energy efficiency and carbon emission calculation method of the data center further includes step S501.

[0114] In step S501, at preset intervals, the first typical value, the second typical value, and the third typical value for each of the energy efficiency parameters are updated, and it is returned to the step of determining the sum of the products of the first typical values respectively corresponding to the energy efficiency parameters and the weights respectively corresponding to the energy efficiency parameters as the first energy efficiency typical value.

[0115] Updating the first, second, and third typical values corresponding to each energy efficiency parameter at preset intervals can make the comprehensive energy efficiency and carbon emissions calculating of data centers more closely aligned with the current development state of the data center industry, keep up with industry development, and make the comprehensive energy efficiency and carbon emissions calculating more scientific and accurate.

[0116] The preset time can be 6 months, one year, or two years, etc. The selection of the preset time can be determined according to the development speed of the data center industry, which is not limited in the present disclosure.

[0117] In addition, in the process of determining the comprehensive energy efficiency of a data center, the relationship between the product of each energy efficiency parameter and its corresponding weight and the first, second, and third energy efficiency typical values can also guide the optimization direction of the comprehensive energy efficiency of the data center, where the optimization direction can be reflected in the form of an energy efficiency optimization report.

[0118] For example, referring to FIG. 7, the energy efficiency and carbon emission calculation method for the data center further includes step S601.

[0119] In step S601, an energy efficiency optimization report is generated based on relationships between the energy efficiency parameters of the data center and the first typical value, the second typical value, and the third typical value for each of the energy efficiency parameters.

[0120] Taking Table 1 as an example, assuming that resource usage effectiveness is represented by PUE, computing power usage effectiveness is represented by $1-\eta_{\text{CPU}}$, and computing power energy effectiveness is represented by η_{CEUE} (calculation method can refer to formula (4)), the first, second, and third typical values of PUE can respectively be 1.2, 1.4, and 1.8. The first, second, and third typical values of computing power usage effectiveness can respectively be 30%, 70%, and 90%. The first, second, and third typical values of computing power energy effectiveness can respectively be 1.2, 1.4, and 1.8.

[0121] Correspondingly, assuming the measured PUE of data center α is 1.9, the representing value of computing power usage effectiveness is 20%, and the computing power energy effectiveness is 1.3, by comparing the PUE, the representing value of the computing power usage effectiveness, and the computing power energy effectiveness with the corresponding first, second, and third typical values, it can be found that the PUE of data center α is poor, and the representing value of the computing power usage effectiveness and the computing power energy effectiveness are excellent. Referring to FIG. 8, it can be indicated in the energy efficiency optimization report that the PUE of data center α is poor, and it is recommended to optimize PUE (optimization methods include but are not limited to improving the cooling method of the data center, etc., which is not limited in the present disclosure) to improve the comprehensive energy efficiency of data center α .

[0122] Assuming the measured PUE of data center β is 1.4, the representing value of computing power usage is 85%, and the computing power energy effectiveness is 1.9. By comparing the PUE, the representing value of the computing power usage effectiveness, and the computing power energy effectiveness with the corresponding first, second, and third typical values, it can be found that the computing power usage effectiveness and the computing power energy effectiveness of data center β are poor, and the PUE is excellent. Referring to FIG. 9, it can be indicated in the energy efficiency optimization report that the computing power usage effectiveness and the computing power energy effectiveness of data center β are poor. It is recommended to optimize the computing power energy effectiveness and the computing power usage effectiveness of data center β to improve its comprehensive energy efficiency.

[0123] The present disclosure also provides examples of feasible ways to obtain energy efficiency parameters. In some embodiments, referring to FIG. 10, the energy efficiency and carbon emission calculation method for the data center includes steps S901 to S904.

[0124] In step S901, operating parameters of the data center are obtained, where the operating parameters are configured to represent resources used by the data center, computing power usage state, and computing power generated by the data center.

[0125] In step S902, the energy efficiency parameters of the data center are calculated based on the operating parameters.

[0126] In step S903, the weights respectively corresponding to the energy efficiency parameters of the data center are determined based on an attribute of the data center, where the attribute of the data center is configured to represent a type, an operating environment, and an operating state of the data center.

[0127] In step S904, the comprehensive energy efficiency of the data center is determined based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters.

[0128] For example, the step S901 may include step S9011.

[0129] In step S9011, the total electrical energy consumption of the data center, the electrical energy consumption of IT equipment, total processor resources of the data center, used processor resources of the data center, total power of the IT equipment, and computing power of the data center are obtained.

[0130] Where the total electrical energy consumption of the data center can be represented in the form of total power P_{total} , measured in kilowatt hours. Correspondingly, the electrical energy consumption of IT equipment in the data center can be represented in the form of power P_{IT} , measured in kilowatt hours. In some embodiments, the total electrical energy consumption of the data center can also be represented as the actual total electrical energy consumption Q_{total} , measured in kilowatts, and the electrical energy consumption of IT equipment can be represented as the electrical energy consumption Q_{IT} of the IT equipment of the data center, measured in kilowatts.

[0131] The total processor resources of a data center can be represented by the primary frequency CPU_{tot} (clock frequency) of the CPU, measured in Hertz (Hz). Correspondingly, the used processor resources in the data center can be represented by the used primary frequency CPU_U of the CPU, measured in Hertz (Hz).

[0132] The computing power of a data center can be represented by the number of floating-point operations performed per second, measured in FLOPS.

[0133] For example, the step S902 may include steps S9021 to S9023.

[0134] In step S9021, a ratio of the electrical energy consumption of the IT equipment to the total electrical energy consumption of the data center is determined as the resource usage effectiveness of the data center.

[0135] When the resource usage effectiveness is represented by PUE, the electrical energy consumption of the IT equipment is represented by the power P_{IT} of IT equipment of the data center, and the total electrical energy consumption of the data center is represented by the total power P_{total} . The step S9021 can be represented by formula (7).

$$PUE = P_{total} / P_{IT} \quad (7)$$

[0136] In step S9022, a ratio of a difference between the total processor resources of the data center and the used processor resources to the total processor resources of the data center is determined as a representing value of the computing power usage effectiveness of the data center.

[0137] The step S9022 can be represented by formula (8).

$$1 - \eta_{CPU} = (CPU_{tot} - CPU_U) / CPU_{tot} \quad (8)$$

[0138] In step S9023, a ratio of the total power of the IT equipment to the computing power of the data center is determined as the computational energy usage efficiency of the data center; and a ratio of a difference between the computational energy usage efficiency of the data center and benchmark computational energy usage efficiency to the benchmark computational energy usage efficiency is determined as the computing power energy effectiveness of the data center.

[0139] The step S9023 can be represented by formula (9) and (10).

$$\eta_{CEUE} = (CEUE \text{ true value} - CEUE \text{ benchmark value}) / CEUE \text{ benchmark value} \quad (9)$$

$$CEUE \text{ true value} = P_{IT} / CP \quad (10)$$

[0140] Where η_{CEUE} represents computing power energy effectiveness, CEUE true value represents computational energy usage efficiency, and CEUE benchmark value represents benchmark computational energy usage efficiency. The benchmark computational energy usage efficiency can be determined by calculating based on the overall computational energy usage efficiency value of national data centers recently released.

[0141] Calculating the energy efficiency parameters of the data center based on the above method has the advantages of simple calculation method, convenient measurement and statistics of various parameters, which is conducive to simplifying the energy efficiency and carbon emission calculation method for the data center and improves the execution efficiency of method.

[0142] Referring to FIG. 11, corresponding to the energy efficiency and carbon emission calculation method for the data center mentioned above, the embodiments of the present disclosure further provide an energy efficiency and carbon emission calculation apparatus for the data center, including a first energy efficiency obtaining module 100 and a first energy efficiency determining module 200.

[0143] The first energy efficiency obtaining module 100 is configured to obtain energy efficiency parameters of the data center, where the energy efficiency parameters include resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness.

[0144] The first energy efficiency determining module 200 is configured to determine weights respectively corresponding to the energy efficiency parameters of the data center; and determine, based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, comprehensive energy efficiency of the data center, where the comprehensive energy is configured to calculate carbon emissions of the data center.

[0145] Referring to FIG. 12, corresponding to the energy efficiency and carbon emission calculation method for the data center mentioned above, the embodiments of the present disclosure further provide another energy efficiency and carbon emission calculation apparatus for the data center, including a second energy efficiency obtaining module 300 and a second energy efficiency determining module 400.

[0146] The second energy efficiency obtaining module 300 is configured to obtain energy efficiency parameters of the data center, where the energy efficiency parameters are used to represent the resource usage effectiveness and the state of computing power usage and output of the data center. The state of computing power usage and output is used to represent the computing power usage effectiveness and computing power energy effectiveness of the data center.

[0147] The second energy efficiency determining module 400 is configured to determine the comprehensive energy efficiency of the data center by integrating the energy efficiency parameters of the data center, where the comprehensive energy efficiency is used to calculate the carbon emissions of the data center.

[0148] The energy efficiency and carbon emission calculation apparatus for the data center provided in this embodiment belongs to the same application concept as the energy efficiency and carbon emission calculation method for the data center provided in the above embodiments of the present disclosure, and can execute the energy efficiency and carbon emission

calculation method for the data center provided in any one of the above embodiments of the present disclosure, and has corresponding functional modules and beneficial effects for executing the energy efficiency and carbon emission calculation method for the data center. The technical details not described in detail in this embodiment can refer to the specific processing content of the energy efficiency and carbon emission calculation method for the data center provided in the above embodiments of the present disclosure, which will not be repeated here.

[0149] Correspondingly, an embodiment of the present disclosure further provides a data center, as shown in FIG. 13, including: IT equipment and a calculating device 30 connected to the IT equipment, where the calculating device 30 is configured to implement the energy efficiency and carbon emission calculation method for the data center described in any one of the above embodiments.

[0150] In actual data centers, the number of IT equipment is usually multiple, which can include server equipment 10, etc. Server equipment 10 can be connected to switch 20 through active optical cables.

[0151] In FIG. 13, in addition to server equipment 10 and switch 20, a router is also shown, and both switch 20 and router are types of network switching devices. These network switching devices can be interconnected, and through these network switching devices, server equipment 10 in the data center can be interconnected.

[0152] The architecture shown in FIG. 13 can also be referred to as a data center network, which can be divided into server layer, edge switch layer, aggregate switch layer, core switch layer, router layer, and optical signal transmission layer. Active optical cables are mainly used to achieve optical communication connections between servers and switches in the server layer.

[0153] The calculating device provided in this embodiment belongs to the same application concept as the energy efficiency and carbon emission calculation method for the data center provided in the above embodiments of the present disclosure, and can execute the energy efficiency and carbon emission calculation method for the data center provided in any one of the above embodiments of the present disclosure, and has corresponding functional modules and beneficial effects for executing the energy efficiency and carbon emission calculation method for the data center. The technical details not described in detail in this embodiment can refer to the specific processing content of the energy efficiency and carbon emission calculation method for the data center provided in the above embodiments of the present disclosure, which will not be repeated here.

[0154] Another embodiment of the present disclosure further provides an electronic device. As shown in FIG. 14, an embodiment of the present specification further provides an electronic device including: a memory and a processor, where the memory stores a computer program, and the processor executes, when executing the computer program, the steps in the energy efficiency and carbon emission calculation method for the data center according to any one of embodiments of the present disclosure described above.

[0155] The internal structure of the electronic device can be shown in FIG. 14, which includes a processor, a memory, a network interface, and an input device that are connected through a system bus. The processor of the electronic device is configured to provide computing and control capabilities. The storage of the central control device includes non-transitory storage medium and internal memory. This non-transitory storage medium stores an operating system and computer programs. This internal storage provides an environment for the operation of the operating system and computer programs in non-transitory storage medium. The network interface of the electronic device is configured to communicate with external terminals through a network connection. The processor executes, when executing the computer program, the steps in the energy efficiency and carbon emission calculation method for the data center according to any one of embodiments of the present disclosure described above.

[0156] The processor may include a main processor, baseband chips, modems, and so on.

[0157] The memory stores programs for executing the technical solution of the present disclosure, as well as an operating system and other critical services. For example, the program may include program code, which includes computer operation instructions. More specifically, memory can include read-only memory (ROM), other types of static storage devices that can store static information and instructions, random access memory (RAM), other types of dynamic storage devices that can store information and instructions, disk storage, flash, and so on.

[0158] The processor can be a general-purpose processor, such as a general-purpose central processing unit (CPU), microprocessor, etc., or an application specific integrated circuit (ASIC), or one or more integrated circuits configured to control the execution of the program of the solution of the present disclosure. It can also be a digital signal processor (DSP), application specific integrated circuit (ASIC), field programmable gate array (FPGA) or other programmable logic devices, discrete gates or transistor logic devices, or discrete hardware components.

[0159] Input devices may include devices that receive user input data and information, such as keyboards, mice, cameras, scanners, light pens, voice input devices, touch screens, pedometers, or gravity sensors.

[0160] Output devices may include devices that allow information to be output to users, such as display screens, printers, speakers, etc.

[0161] Communication interfaces can include devices such as transceivers configured to communicate with other devices or communication networks, such as Ethernet, Radio Access Network (RAN), Wireless Local Area Network (WLAN), etc.

[0162] The processor executes programs stored in the memory and calls other devices, which can be configured to implement various steps of the energy efficiency and carbon emission calculation method for the data centers provided in any one of the above embodiments of the present disclosure.

[0163] The electronic device may further include a display component and a voice component. The display component may be a liquid crystal display screen or an electronic ink display screen. The input device of the electronic device may be a touch layer covered on the display component, a key, trackball, or touchpad provided on the electronic device housing, or an external keyboard, touchpad, or mouse.

[0164] Those skilled in the art can understand that the structure shown in FIG. 14 is only a block diagram of a part of the structure related to the solution in the present disclosure, and does not constitute a limitation on the electronic devices to which the solution in the present disclosure is applied. Specific electronic devices may include more or fewer components than shown in the figure, or combine certain components, or have different component arrangements.

[0165] In addition to the methods and devices described above, the energy efficiency and carbon emission calculation method for the data center provided in the embodiments of the present disclosure can also be a computer program product, which includes computer program instructions that, when executed by a processor, cause the processor to perform the steps of the energy efficiency and carbon emission calculation method for the data center according to any one of the embodiments of the present disclosure.

[0166] The computer program product can be programmed in any combination of one or more programming languages to write program code for performing the operations of the embodiments described herein, including object-oriented programming languages such as Java, C++, and conventional procedural programming languages such as "C" or similar programming languages. Program code can be executed entirely on a user computing device,

partially on a user device, as a standalone software package, partially on a user computing device and partially on a remote computing device, or entirely on a remote computing device or server.

[0167] In addition, the embodiments of the present disclosure further provide a computer-readable storage medium on which a computer program is stored. The computer program is executed by a processor to perform the steps of the energy efficiency and carbon emission calculation method for the data center according to any one of the embodiments of the present disclosure.

[0168] A person of ordinary skill in the art can understand that implementing all or part of the processes in the above embodiments can be accomplished by instructing relevant hardware through a computer program. The computer program can be stored in a non-transitory computer-readable storage medium, and when the computer program is executed, it may include the processes of the embodiments of the above methods. Any reference to memory, storage, database or other media used in the embodiments provided in the present disclosure may include non-transitory and/or transitory memory. Non transitory memory can include read-only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable programmable ROM (EEPROM), or flash memory. The transitory memory can include random access memory (RAM) or external cache memory. As an illustration and not a limitation, RAM can be obtained in various forms, such as static RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDRSDRAM), enhanced SDRAM (ESDRAM), synchronous link DRAM (SLDRAM), Rambus direct RAM (RDRAM), direct Rambus Dynamic RAM (DRDRAM), and Rambus Dynamic RAM (RDRAM).

[0169] The various technical features of the above embodiments can be combined arbitrarily. In order to make the description concise, not all possible combinations of the various technical features in the above embodiments have been described. However, as long as there is no contradiction in the combination of these technical features, they should be considered within the scope of the present disclosure.

[0170] The above embodiments only express several embodiments of the present disclosure, and their descriptions are more specific and detailed, but should not be understood as limiting the scope of the solutions provided by the embodiments of the present disclosure. It should be pointed out that those skilled in the art can make several modifications and improvements without departing from the concept of the present disclosure, and these all belong to the

protection scope of the present disclosure. Therefore, the protection scope of the present disclosure should be based on the appended claims.

CLAIMS

1. An energy efficiency and carbon emission calculation method for a data center, comprising:

obtaining energy efficiency parameters of the data center, wherein the energy efficiency parameters comprise resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness;

determining weights respectively corresponding to the energy efficiency parameters of the data center; and

determining, based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, comprehensive energy efficiency of the data center, wherein the comprehensive energy is configured to calculate carbon emissions of the data center.

2. The method according to claim 1, wherein determining, based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, the comprehensive energy efficiency of the data center comprises:

determining a sum of products of the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters as the comprehensive energy efficiency of the data center.

3. The method according to claim 2, further comprising:

for each of the energy efficiency parameters, obtaining a first typical value, a second typical value, and a third typical value for the energy efficiency parameter, wherein the first typical value represents a typical value for the energy efficiency parameter in a first energy efficiency region, the second typical value represents a typical value for the energy efficiency parameter in a second energy efficiency region, and the third typical value represents a typical value for the energy efficiency parameter in a third energy efficiency region; wherein energy efficiency in the first energy efficiency region, the second energy efficiency region, and the third energy efficiency region represented by the energy efficiency parameter sequentially decreases;

determining a sum of products of first typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters as a first energy efficiency typical value;

determining a sum of products of second typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters as a second energy efficiency typical value;

determining a sum of products of third typical values respectively corresponding to the energy efficiency parameters and weights respectively corresponding to the energy efficiency parameters as a third energy efficiency typical value;

determining a first critical value between the first energy efficiency typical value and the second energy efficiency typical value;

determining a second critical value between the second energy efficiency typical value and the third energy efficiency typical value; and

determining, based on a relationship between the comprehensive energy efficiency of the data center and the first critical value and the second critical value, an energy efficiency state of the data center, wherein the efficiency state is configured to represent an energy efficiency level of the comprehensive energy efficiency of the data center.

4. The method according to claim 3, further comprising:

determining, based on the first critical value and the second critical value, an energy efficiency benchmark value of the data center; and

determining, based on the energy efficiency benchmark value of the data center, a carbon emission benchmark value of the data center.

5. The method according to claim 3, further comprising:

at preset intervals, updating the first typical value, the second typical value, and the third typical value for each of the energy efficiency parameters, and returning to the step of determining the sum of the products of the first typical values respectively corresponding to the energy efficiency parameters and the weights respectively corresponding to the energy efficiency parameters as the first energy efficiency typical value.

6. The method according to claim 3, further comprising:

generating an energy efficiency optimization report based on relationships between the energy efficiency parameters of the data center and the first typical value, the second typical value, and the third typical value for each of the energy efficiency parameters.

7. The method according to claim 1, wherein obtaining the energy efficiency parameters of the data center comprises:

obtaining operating parameters of the data center, wherein the operating parameters are configured to represent resources used by the data center, computing power usage state, and computing power generated by the data center; and

calculating the energy efficiency parameters of the data center based on the operating parameters.

8. The method according to claim 7, wherein obtaining the operating parameters of the data center comprises:

obtaining total electrical energy consumption of the data center, the electrical energy consumption of IT equipment, total processor resources of the data center, used processor resources of the data center, total power of the IT equipment, and computing power of the data center;

wherein calculating the energy efficiency parameters of the data center based on the operating parameters comprises:

determining a ratio of the electrical energy consumption of the IT equipment to the total electrical energy consumption of the data center as the resource usage effectiveness of the data center;

determining a ratio of a difference between the total processor resources of the data center and the used processor resources to the total processor resources of the data center as a representing value of the computing power usage effectiveness of the data center;

determining a ratio of the total power of the IT equipment to the computing power of the data center as the computational energy usage efficiency of the data center; and

determining a ratio of a difference between the computational energy usage efficiency of the data center and benchmark computational energy usage efficiency to the benchmark computational energy usage efficiency as the computing power energy effectiveness of the data center.

9. The method according to any one of claims 1-8, wherein determining the weights respectively corresponding to the energy efficiency parameters of the data center comprises:

determining, based on an attribute of the data center, the weights respectively corresponding to the energy efficiency parameters of the data center, wherein the attribute of

the data center is configured to represent a type, an operating environment, and an operating state of the data center.

10. An energy efficiency and carbon emission calculation method for a data center, comprising:

obtaining energy efficiency parameters of the data center, wherein the energy efficiency parameters are configured to represent the resource usage effectiveness and computing power usage and output state of the data center; and

determining comprehensive energy efficiency of the data center by integrating the energy efficiency parameters of the data center.

11. An energy efficiency and carbon emission calculation apparatus for a data center, comprising:

a first energy efficiency obtaining module, configured to obtain energy efficiency parameters of the data center, wherein the energy efficiency parameters comprise resource usage effectiveness, computing power usage effectiveness, and computing power energy effectiveness; and

a first energy efficiency determining module, configured to determine weights respectively corresponding to the energy efficiency parameters of the data center; and determine, based on the energy efficiency parameters of the data center and the weights respectively corresponding to the energy efficiency parameters, comprehensive energy efficiency of the data center, wherein the comprehensive energy is configured to calculate carbon emissions of the data center.

12. An electronic device, comprising: one or more memories and one or more processors; wherein the one or more memories are connected to the one or more processors, and the one or more memories are configured to store a program;

wherein the one or more processors are configured to implement, by running the program stored in the one or more memories, the energy efficiency and carbon emission calculation method for a data center according to any one of claims 1-10.

13. A storage medium, wherein a computer program is stored on the storage medium, and when the computer program is executed by one or more processors, the energy efficiency and

carbon emission calculation method for a data center according to any one of claims 1-10 is implemented.

14. A data center, comprising: IT equipment and calculating equipment connected to the IT equipment, wherein the calculating equipment is configured to implement the energy efficiency and carbon emission calculation method for a data center according to any one of claims 1-10.